

AMENDMENTS TO THE SPECIFICATION

On page 1 and in the Abstract, amend the title of the application as follows:

~~METHOD OF FORMING~~ CMOS DEVICE HAVING RETROGRADE N-WELL AND P-WELL

Before paragraph [0001], insert:

This application is a divisional of Serial No. 10/063,406; filed on April 19, 2002.

Amend the following paragraphs as follows:

[0011] With reference to Fig. 1, a 200 nanometer (nm) layer of polycrystalline silicon (polysilicon) 12 is deposited on a semiconductor substrate 10. The substrate 10 can be silicon, silicon-germanium, gallium arsenide, or any other semiconductor base in which CMOS devices can be formed. Typically the twin tubs are formed in the substrate 10 after isolation regions 11B (for example, shallow trench isolation) have been formed, ~~but these are not shown in the drawing for ease of illustration.~~ Further, immediately prior to the sequence of steps described herein, a protection layer 11A such as a thin oxide (for example, if the substrate is silicon, silicon oxide about 60 angstroms thick) is preferably grown on the substrate; ~~again, for ease of illustration this thin protection layer is not shown.~~ The polysilicon layer 12 can be made of other materials (such as silicon nitride and silicon oxide) that can be deposited and etched in the same manner as the polysilicon layer 12, as described in more detail below. The polysilicon layer 12 is preferably of a thickness of approximately 100-300nm. Other thicknesses could be used.

[0013] Subsequently, as shown in Fig. 3, a series of implant steps are carried out to define the retrograde n-well 16, comprising a deep high dose implant ~~16C~~ 16A at an energy of 850,000 electron volts, and a dosage of 5.2 times 10 to the 13th energy per square

centimeter (as abbreviated hereafter, 850 keV, 5.2×10^{13} per cm^2 cm^2), intermediate dose implant 16B (550 keV, 1.25×10^{12} per cm^2 cm^2) and low dose implant 16A (50 keV, 5×10^{11} per cm^2 cm^2), all of phosphorous (arsenic could also be used, with appropriate changes in the doses and energies). Note that during this set of implant steps the photoresist is thick enough to prevent ions from substantially penetrating through the polysilicon layer 12. A final, shallower implant could also be carried out to more precisely control dopant levels at the surface of substrate 10. Obviously the powers and dosage densities can be varied, so long as the overall implant profile (featuring deep high dose implant, intermediate dose implant, and shallow lower dose implant) is provided. Moreover, additional implants could be added.

[0014] Then, as shown in Fig. 4, the exposed portion of the layer 12 is removed (preferably by reactive ion etching in a bromine or chlorine-based ambient), and photoresist 14 is removed by plasma etching in an oxygen ~~environment~~, environment so that a portion of the polysilicon layer 12 remains. Then a boron implant is done at 550 keV, 2.5×10^{14} per cm^2 cm^2 to form a deep p-type implant region ~~18C~~ 18A. The present inventors have found that by doing this deep implant in the presence of a relatively thin masking material (the 200nm polysilicon 12), boron scattering during this implant step is substantially eliminated. The threshold voltages of the NFETs formed in the p-well do not vary as a function of distance from the p-well/n-well interface. Specifically, experimental results showed that threshold voltage shifts of FETs formed within approximately 1.5 μm of the interface between the n-well and the p-well, as compared to FETs formed elsewhere, were either zero or negligible (not greater than 10mV). Note also that this dosage and energy of boron results in a portion of region ~~18C~~ 18A immediately below the deepest n-well implant ~~16C~~ 16A which decreases junction capacitance and hence enhances the switching speed of the resulting transistors.

[0015] Finally, as shown in Fig. 5, the polysilicon layer 12 is stripped, a new photoresist between 1800-2500nm is deposited and imaged to form a second implant blocking mask ~~20~~, 20. An intermediate dose implant 18B (150 kEv, 1.25×10^{12} per ~~cm²~~ cm²) and low dose implant ~~18A~~ 18C (45 kEv, 5×10^{11} per ~~cm²~~ cm²) are provided to define the retrograde p-well 18. Again, a final, shallower implant could also be carried out to more precisely control dopant levels at the surface of substrate 10. Again, the dosages and number of implants can be varied as in the case of the n-well 16 as described above. The inventors found that at these dosages and powers there was no evidence of boron scattering, hence the thicker implant blocking mask 20 can be used. FETs (not shown) are subsequently formed in the respective wells to provide the final CMOS device.